

1 METHOD AND APPARATUS FOR SPRAYING

2
3 The present invention relates to a method and apparatus
4 for low air pressure spraying. Particularly, but not
5 exclusively, the invention is applicable to spray guns
6 for the application of paint and like material surface
7 treatments, particularly water-based paints.

8
9 The use of spray guns for application of paints is well
10 known. However, it has been found that when water-
11 based, high gloss paints are sprayed through a high
12 pressure or conventional spray gun, the level of gloss
13 is reduced. This is also true of the high volume-low
14 pressure type of spray gun which operate at only 10psi
15 air cap pressure.

16
17 Tests carried out at various pressures have shown that
18 the loss of gloss is due to air bubbles rising to the
19 surface of the paint as it dries. It has been found
20 that the greater the pressure used to spray the paint,
21 the more air bubbles appear. The cause of the bubbles
22 is that dissolved air is being released from the water
23 as the paint dries. The greater the air pressure when
24 the paint is sprayed, the greater the volume of
25 dissolved air and the greater the number of bubbles.

1 If the air pressure is low but the volume is high,
2 gloss levels are reduced. To achieve the desired gloss
3 levels with this type of paint it is necessary to
4 design a spray gun that will operate at very low air
5 pressures and very low air volumes. It must achieve
6 acceptable levels of atomization, have sufficient
7 energy to transfer the paint at an acceptable rate to
8 the surface of the target, and expand the natural cone
9 of spray into a useful fan pattern.

10
11 In the past, spray guns have used air pressures between
12 40 and 90 psi, and these high pressures cause a cushion
13 of air to be formed on the surface of the product being
14 treated. This cushion causes some of the sprayed
15 material to bounce back and be displaced laterally by
16 the following airflow to be lost in the surrounding
17 air.

18
19 Accordingly, this type of spray gun is very
20 inefficient. Rarely are transfer efficiencies greater
21 than 40% and more often nearer 30%. The waste paint
22 material produces unacceptable emissions of volatile
23 organic compounds and leaves a solid residue which can
24 remain floating in the air for some time. These can be
25 highly toxic and damaging to the atmosphere and health.
26 To overcome these problems, it is necessary to reduce
27 the air pressure and air volume used in such guns.
28 Therefore, the environmental requirements for an
29 acceptable spray gun are similar to those required for
30 achieving a good gloss in water-based paints.

31
32 If the air pressure is reduced on a spray gun that was
33 originally designed for high pressure use, the
34 turbulence and restrictions in internal air passages
35 and the air cap cause a loss of air speed and a
36 reduction in air volume. The result of this is low

1 paint transfer rates, poor atomization and an inferior
2 paint finish. However, transfer efficiency is
3 improved. If the air volume is increased while keeping
4 the pressure low, the ratio of air to paint increases
5 and the problems experienced with high pressure will
6 return depending on the increase in volume.

7
8 Existing high pressure spray guns have been modified to
9 operate at low pressures, but the complexity of the
10 designs and the intricate interconnecting drilled
11 passages do not permit good air flow. In an effort to
12 overcome the poor performance, air cap ring gaps were
13 increased, resulting in a substantial increase in air
14 consumption. This type of spray gun has become known
15 as the high volume-low pressure (HVLP) gun.

16
17 More specifically, in HVLP spray guns the means for
18 actuating the control valves within the gun have had
19 considerable shortcomings. For example, it is
20 commonplace for the stem of the needle valve and its
21 associated compression spring and housing to extend
22 through the main air flow passage to the nozzle,
23 thereby leading to significant restrictions in the air
24 flow path.

25
26 Likewise, in order to provide a convenient means for
27 actuating the stem of the air flow and fluid needle
28 valves, the main nozzle of the apparatus is mounted on
29 a forward projection of the apparatus so as to leave a
30 free space to accommodate the arc of movement of the
31 valve control trigger.

32
33 Moreover, since the same trigger operates both the
34 liquid and air control valves, the progressive control
35 from on to off operating characteristics of the air
36 control valve can be restricted in certain operating

1 conditions where the liquid control valve has been
2 manually adjusted to such a point that it affects the
3 ability of the trigger to operate both valves
4 simultaneously through the full range of movement.

5
6 The object of the present invention is to provide a
7 method and apparatus for spraying paint and other
8 surface treatment liquids, offering improvements in
9 relation to one or more of the matters discussed above,
10 or generally.

11
12 According to a first aspect of the invention there is
13 provided an apparatus for spraying liquid surface
14 treatment material, said apparatus having a housing, a
15 liquid inlet for supply of the liquid surface treatment
16 material, a gas inlet for supply of pressurised gas to
17 be mixed with the liquid surface treatment material, an
18 outlet nozzle through which the gas and liquid surface
19 treatment material is sprayed, a control valve adapted
20 to regulate the supply of the liquid surface treatment
21 material to the outlet nozzle, a gas valve operable
22 between an open position and a closed position, a first
23 communicating passageway connecting said gas inlet to
24 said gas valve, and a second communicating passageway
25 connecting said gas valve to said outlet nozzle;
26 wherein said second passageway is provided with a
27 stepped portion therein so that a gas vortex is created
28 therethrough.

29
30 Preferably, said second passageway is offset from said
31 first passageway. Preferably, said second passageway
32 is substantially conical in shape. Preferably, said
33 second passageway includes an inlet and an outlet,
34 wherein said passageway is tapered from said inlet to
35 said outlet. Preferably, said taper is between 1 and
36 15°.

1 Preferably, said stepped portion of said second
2 passageway comprises a ledge whose width tapers up to a
3 maximum of 10% of the radius of said second passageway
4 at the level of the stepped portion.

5
6 Preferably, said second passageway has a radius of
7 curvature at said outlet so as to provide gas to the
8 nozzle in a substantially horizontal direction.

9
10 Preferably, the longitudinal axis of said outlet nozzle
11 extends across said second passageway. Preferably, the
12 axis of symmetry of said ledge is offset from said
13 longitudinal axis of said outlet nozzle, thereby
14 inducing a vortex in the air flowing through said
15 passageway.

16
17 According to a second aspect of the invention there is
18 provided an apparatus for spraying liquid surface
19 treatment material, said apparatus having a housing, a
20 liquid inlet for supply of the liquid surface treatment
21 material, a gas inlet for supply of pressurised gas to
22 be mixed with the liquid surface treatment material, an
23 outlet nozzle through which the gas and liquid surface
24 treatment material is sprayed, a control valve adapted
25 to regulate the supply of the liquid surface treatment
26 material to the outlet nozzle, a gas valve operable
27 between an open position and a closed position, a first
28 communicating passageway connecting said gas inlet to
29 said gas valve, and a second communicating passageway
30 connecting said gas valve to said outlet nozzle;
31 wherein said second passageway is axially offset from
32 said first passageway and is substantially conical in
33 shape, and wherein said second passageway includes an
34 inlet and an outlet and is tapered from said inlet to
35 said outlet at an angle of taper of between 1 and 15°.

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1 Preferably the apparatus further comprises a trigger
2 means, whereby said trigger means is adapted to operate
3 both of said control valve and said gas valve.

4
5 Preferably, said gas valve is an axially-sliding piston
6 valve. Preferably, said control valve is a liquid
7 control needle valve.

8
9 Preferably, said outlet nozzle is controlled by said
10 liquid control needle valve.

11
12 Preferably, said piston valve produces an annular air
13 jet in said second passageway. The piston valve may be
14 tapered or parallel. In addition, an air control valve
15 stem is provided which is connected to the piston valve
16 and operated by said trigger means.

17
18 Preferably, said piston valve comprises inner and outer
19 co-axial apertured sleeves, wherein said inner sleeve
20 is located within said outer sleeve and is rotatably
21 adjustable relative to said outer sleeve.

22
23 Preferably, the liquid control needle valve is
24 controlled by said trigger means via an axially-sliding
25 sleeve or slipper member situated on a rearward portion
26 of the housing. Preferably, it is also provided with a
27 rotational flow adjustment means to adjust the flow
28 rate of the liquid.

29
30 Preferably, said flow adjustment means comprises a stem
31 member, a rotational adjuster, and a return spring,
32 said stem member being threaded at its rearmost
33 extremity to accept the rotational adjuster.

34 Preferably, said stem member is actuated externally by
35 the trigger means, and is returned to its initial
36 position by a return spring.

1 and a lower portion, wherein said upper portion is
2 axially offset from said lower portion and is
3 substantially conical in shape. Preferably, said upper
4 portion of said passageway includes an inlet and an
5 outlet and is tapered from said inlet to said outlet at
6 an angle of taper of between 1 and 15°.

7
8 Preferably, the mixing of said liquid and said annular
9 gas jet is controlled by a trigger valve mechanism on
10 said spray apparatus. Preferably, said trigger valve
11 mechanism comprises:

12 a gas valve operable between an open position and
13 a closed position;

14 a control valve adapted to regulate the supply of
15 the liquid to be sprayed; and

16 a trigger means;

17 whereby said trigger means is adapted to operate
18 both of said gas and control valves.

19
20 Preferably, said control valve is a liquid control
21 needle valve. Preferably, said gas valve is an
22 axially-sliding piston valve. Preferably said piston
23 valve comprises an inner apertured sleeve and an outer
24 apertured sleeve, said inner and outer sleeves being
25 co-axial, and wherein said inner sleeve is located
26 within said outer sleeve and is rotatably adjustable
27 relative to said outer sleeve.

28
29 Embodiments of the invention will now be described by
30 way of example with reference to the accompanying
31 drawings in which :-

32
33 Figure 1 shows a first embodiment of a spray gun
34 according to the present invention;

35
36 Figure 2 shows a section through the spray gun of

1 Figure 1 having pressure feed and offset air passages;
2
3 Figure 3 shows a second embodiment of a spray gun
4 according to the present invention;
5
6 Figure 4(a) shows a section through the spray gun of
7 Figure 3 having offset air passages and a tapered upper
8 air passage;
9
10 Figure 4(b) is a sectional view along line "A-A" of
11 Figure 4(a);
12
13 Figure 4(c) is a sectional view along line "B-B" of
14 Figure 4(a), showing the stepped portion of the upper
15 air passage;
16
17 Figure 5 shows a third embodiment of a spray gun
18 according to the present invention;
19
20 Figure 6(a) shows a section through the spray gun of
21 Figure 5;
22
23 Figure 6(b) shows the component parts of the piston
24 valve of the spray gun of Figures 5 and 6(a); and
25
26 Figure 6(c) shows a sectional view along line "VI-VI"
27 of Figure 6(a).
28
29 As shown in Fig 1, a first embodiment of a spray
30 apparatus 10 comprises a body or housing 12 having a
31 nozzle 14, an operating trigger 40, and a regulating
32 valve 52. Nozzle 14 is secured to the housing 12 by a
33 threaded ring 11.
34
35 Figure 2 shows a section view through the spray gun
36 which shows the components of the apparatus 10 in more

1 detail. The apparatus 10 has an air supply connection
2 16, a pressurized material supply connection 18, an air
3 control valve stem 20, and a liquid control valve 22.
4 It will be noticed that in this embodiment, and each of
5 the subsequent embodiments described herein, the air
6 supply connection 16 and material supply connection 18
7 and their respective supply passages are located in the
8 handle portion of the apparatus 10. By locating both
9 supply connections 16, 18 in the handle portion, the
10 apparatus 10 can be packaged in a more compact manner
11 than prior art apparatus. Furthermore, by being
12 located in the handle the supply passages are free from
13 the internal restrictions which can hamper the
14 performance of known apparatus.

15
16 A tapered piston valve 23 controls the supply of air to
17 the nozzle 14 in order to regulate the spray pattern.
18 The nozzle 14 provides a central jet 15 controlled by
19 the liquid control needle valve 22, and an annular air
20 jet 28 controlled by the piston valve 23. The air
21 control valve stem 20 connects to an axially-sliding
22 piston 24 to effect progressive throttling of the air
23 flow. The stem 20 is pushed by an operating trigger
24 40.

25
26 The air supply connection 16 is coupled to a compressor
27 (not shown) which provides air under pressure to the
28 air supply connection 16. Connection 18 is supplied by
29 a reservoir (not shown) containing paint or like
30 material to be sprayed.

31
32 The liquid control needle valve 22 has a rotational
33 adjuster 44 and is controlled by the trigger 40 through
34 a sleeve member 46 which slides on a rearward portion
35 48 of the housing 12. The trigger 40 acts on the
36 sleeve 46 by way of a flange (not shown) on the sleeve

1 46, thereby opening the needle valve 22 to allow liquid
2 to pass through.

3
4 A regulating valve 52 is positioned whereby the jet 15
5 produced by nozzle 14 is regulated from a natural cone
6 to a fan pattern by air from side jets 17.

7
8 The air passage 38 connects the air supply connection
9 16 with the piston valve 23. The air control valve
10 stem 20 controls the air flow through a pair of offset
11 passages 38 and 39, where the lower passage 38 and the
12 upper passage 39 are offset to create a vortex within
13 the upper passage 39, thereby accelerating the gas flow
14 through said upper passage 39. A return spring 25 is
15 also provided in order to return the piston 24 and stem
16 20 to their extended position when released. The
17 piston valve 23 has two apertured rotational sleeves 26
18 which can be adjusted by a lever 21 to either line up,
19 close off or partially close the apertures, thereby
20 increasing or decreasing the vortex in the passage 39.
21 Thus, the pressure in the gun can be regulated to offer
22 variable pressure sprays. A more detailed description
23 of the operation of the piston valve 23 is given later.

24
25 The liquid control valve needle 22 has a stem member 42
26 which passes through sleeve member 46 and is threaded
27 at its rearmost extremity to accept the rotational
28 adjuster 44. The rotational adjuster 44 allows fine
29 position adjustment of the fluid control needle 22.
30 Trigger 40 actuates the needle member 22 externally of
31 the housing 12. An internal return spring (not shown)
32 returns the needle 22 to its rest position. Liquid to
33 be sprayed is fed to the needle valve 22 from
34 connection 18 via a radial port 56.

35
36 Figure 3 shows a second embodiment of a spray gun

1 apparatus 10 according to the present invention.
2 Externally, the second embodiment appears similar to
3 the apparatus of the first embodiment. However, the
4 sectional views of Figures 4(a)-(c) highlight the
5 difference between the two embodiments.

6
7 Figures 4(a)-(c) show views of the second embodiment of
8 the spray gun 10 in which upper air passage 39 has been
9 modified to assist the creation of the vortex within
10 the upper passage 39. Figure 4(b) shows the tapering
11 of the upper passage 39 to assist the acceleration of
12 the gas therein. The best acceleration results have
13 been produced when the tapering is between 0 and 10°.
14 Figure 4(c) shows the cross-section B-B of the upper
15 passage 39 at its inlet, wherein a stepped portion 50
16 is provided. For the most effective vortex, the
17 stepped portion 50 should encompass approximately 10%
18 of the circumference of the upper passage 39.

19
20 The vortex is created in the upper passage 39 as the
21 gas passes through the inlet of upper passage 39 over
22 the stepped portion 50, which can be best seen in Fig
23 4(b). As the gas passes over the stepped portion 50,
24 the increased area causes the gas to swirl in the
25 passage, thereby creating the vortex which produces a
26 gas acceleration upwards through the upper passage 39.
27 The tapering of the upper passage 39 ensures that the
28 vortex is sustained until it reaches the outlet of the
29 upper passage 39 at nozzle 14.

30
31 As with each of the embodiments described herein, the
32 liquid control valve needle 22 passes through the
33 uppermost chamber 51 of the upper passage 39. This is
34 best seen in Figure 4(b), where the valve 22 passes
35 directly through the chamber 51 in such a way as to not
36 hinder the vortex created in the upper passage 39.

1 Thus, the vortex flows through the chamber 51
2 relatively unhindered by the valve 22 as the gas flows
3 around the outside of the valve 22, and the vortex is
4 not destroyed by the valve 22.

5
6 Aside from the amendments to the passage 39, this
7 embodiment of the spray gun 10 is constructed and
8 operated substantially in the same manner as the spray
9 gun 10 of figure 1.

10
11 The third and final of the preferred embodiments
12 described is shown in Figures 5 and 6(a)-(c). Again,
13 externally, the spray gun 10 is similar in appearance
14 to the other embodiments, with the majority of the
15 components previously described above being used.
16 However, the third embodiment differs in the operation
17 of the piston valve assembly 23 which produces the
18 vortex.

19
20 The use of a pair of apertured sleeves 26a,26b within
21 the piston valve assembly 23 was first discussed in the
22 description of the first embodiment above. However,
23 the individual components of the piston valve assembly
24 23 are best seen in Figure 6(b). The valve assembly 23
25 consists of an apertured outer sleeve 26b and an
26 apertured inner sleeve 26a, and each of the sleeves
27 26a,26b has a pair of apertures 61,62. On each sleeve
28 26a,26b, the apertures 61,62 are located diametrically
29 opposite one another, thereby permitting gas to pass
30 through the sleeves 26a,26b unhindered.

31
32 Figure 6(a) shows the manner in which the various
33 components of the valve assembly 23 co-operate. The
34 inner sleeve 26a is located inside the outer sleeve
35 26b, with the apertures 61,62 of the two sleeves
36 26a,26b being axially aligned to allow gas to pass

1 directly through the sleeves 26a,26b. The inner sleeve
2 26a is fitted with a lever 21 so that the inner sleeve
3 26a may be rotated relative to the outer sleeve 26b. A
4 return spring 25 is located within the sleeves 26a,26b
5 with a piston 24 positioned thereon. The piston 24
6 receives the spring 25 on one end 24a and an air
7 control valve stem 20 on the other end 24b. The stem
8 20 has a flange 20a which locates in the second end 24b
9 of the piston so that the stem 20 may act on the piston
10 24.

11
12 Thus, in order to operate the piston valve assembly 23,
13 the trigger 40 is pulled towards the housing 12 of the
14 apparatus 10. As the trigger 40 is pulled, it acts on
15 the valve stem 20 which in turn acts on the piston 24.
16 The action of the trigger 40 thus pushes the piston 24
17 away from the air passages, thereby permitting the gas
18 to pass through the valve assembly 23 by way of the
19 aligned apertures 61,62 in the inner and outer sleeves
20 26a,26b. When the trigger 40 is released, the spring
21 25 pushes the piston 24, stem 20, and trigger 40 back
22 to their original positions, and gas can therefore no
23 longer pass through the valve assembly 23.

24
25 Figure 6(c) shows how the alignment of the apertures
26 61,62 on the inner and outer sleeves 26a,26b can be
27 varied to improve the vortex generation in the upper
28 air passage 39. The lever 21 can be rotatably adjusted
29 in order to rotate the inner sleeve 26a relative to the
30 fixed outer sleeve 26b. Thus, as is seen in Figure
31 6(c), the apertures 61,62 can be offset from each
32 other. This offsetting of the apertures 61,62 creates
33 a lip portion 63, where a portion of the inner sleeve
34 26a partly blocks the aperture 61 of the outer sleeve
35 26b. Thus, the gas flowing through the valve assembly
36 23 is disrupted thereby creating the vortex in the

1 upper passage 39 of the apparatus 10.

2

3 In use, each of the embodiments is operated as follows:

4 The reservoir of material to be sprayed delivers the

5 material to central jet 15 under the control of needle

6 valve 22 where it is mixed with air delivered via air

7 passages 38 and 39. The operation of the gun is

8 initiated by trigger 40 operating air control valve

9 stem 20 and liquid control valve 22.

10

11 The present invention provides a method and apparatus

12 for spraying that addresses the limitations and

13 inefficiencies of prior spray guns. As it may operate

14 at pressures as low as 1.5psi in the air cap and at air

15 volumes as low as 4cfm, energy savings are achieved.

16 The very low pressures allow a very high transfer

17 efficiency to be achieved which is an added advantage

18 when used with paints containing volatile organic

19 compounds.

20

21 The present invention permits the trigger 40 to operate

22 the air control valve 23 and the fluid control valve 22

23 simultaneously, without restricting the operation of

24 either, regardless of the adjustment of the other. The

25 stems of both the fluid control needle valve 22 and air

26 control piston valve 23 operate in parallel to each

27 other, yet independently of each other.

28

29 The above permits a straight, unobstructed, large

30 diameter air passage 38 to the air valve 23 while also

31 permitting a short, straight air passage 39 to the air

32 cap 52 and a large diameter fluid passage.

33

34 In addition, by offsetting the air passages 38,39, gas

35 acceleration may be achieved by means of a vortex

36 created by the gas passing through these passages

1 38,39. With gas acceleration in the head portion of
2 the apparatus 10, the increased speed of the gas
3 created by the vortex leads to an increase in air speed
4 at the nozzle 14 and thereby an increase in material
5 sprayed by the gun. Therefore, although gas is
6 introduced to the apparatus 10 from a compressor at
7 relatively low pressure, by having the air passages
8 38,39 arranged in the offset position a gas
9 acceleration is achieved with a consequential increase
10 in efficiency at the nozzle 14. Moreover, the gas
11 acceleration is further improved by the provision of a
12 pair of adjustable, apertured sleeves 26a,26b which can
13 either increase or decrease gas flow into the vortex
14 from the air valve 23 depending on the alignment of the
15 apertures 61,62.

16

17 The features of the present invention:

- 18 i) reduce the compressed air volume required;
19 ii) reduce the pressure of said compressed air;
20 iii) reduce energy losses;
21 iv) improve exit air speed;
22 v) increase depression at the fluid nozzle; and
23 vi) reduce resistance to fluid flow.

24

25 The internal surface area of the air passages is
26 approximately 50% less than a representative selection
27 of spray guns currently available.

28

29 The trigger to air cap air passage length is 75% less
30 than with the representative selection.

31

32 Total air passage length is approximately 40% less than
33 with the representative selection.

34

35 Input air pressure is 75% lower than the average of the
36 representative selection.

